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ABSTRACT

This study investigated the effects of the use of hand-held calculators on problem solving and computational skills of elementary school students. It also considers the resulting implications for curriculum change. Evaluation focused on achievement in problem solving, computational skills, and number concepts of kindergarten, second grade, and fourth-grade students. The investigation examined differences in achievement test scores in mathematics of the experimental group which used calculators and the control groups which did not use calculators. The experimental group scored significantly higher than the control group in kindergarten. The data seem to indicate that there is no significant difference in achievement between the experimental and control groups in second and fourth grade. This seems to indicate that calculator use has no detrimental effect on mathematics achievement at these grade levels. An attempt to access parent attitudes was also made. Results of this questionnaire are reported. Appendices A, B, and C contain suggested calculator activities for kindergarten, second grade, and fourth grade, respectively. The parent questionnaire and various tabulations of responses to it make up the remainder of the appendices. (Author/MK)

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An Investigation of the Use of Hand - Held Calculators by Students In Elementary School

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RESEARCH MONOGRAPH NO. 32

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AN INVESTIGATION OF THE USE OF HAND-HELD CALCULATORS BY STUDENTS IN ELEMENTARY SCHOOL

by

Totsye J. Conner

Winter, 1980

P. K. Yonge Laboratory School
College of Education
University of Florida
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PREFACE

Technological, social, political, and economic changes are occurring in our society at an unprecedented rate. Those changes must be taken into account in determining what we teach and how we teach. We must prepare our children and youth for conditions they will face in the future rather than the kind of society in which people have lived in the past.

There is no area in which technological change is occurring more rapidly than in the field of mathematics. Use of the calculator and the computer is making fundamental changes in the ways in which we solve problems and perform mathematical tasks. In what ways must the mathematics curriculum be changed to reflect those changes?

The study reported in this monograph represents a first step in attempting to answer one aspect of that question. It found that kindergarten children who participated in the study made greater progress when hand-held calculators were used without modifying the mathematics curriculum otherwise. Progress of second and fourth grade students was not significantly affected.

Florida's literacy test results and many research studies present clear evidence that large numbers of our students do not learn how to use mathematics to solve real life problems. Is this because we devote so much time to teaching computational algorithms to students who are not motivated to acquire skills that are not seen as relevant? If so, should we reverse the traditional ordering of mathematics instruction, placing initial emphasis upon application by use of calculators for calculations, and then teach algorithms after children have observed their relevance? Do we need to re-examine and extend our preceptions of what constitutes relevant mathematics instruction for tomorrow's world?

At the P. K. Yonge Laboratory School, we intend to continue to explore these questions. Not only will we be conducting additional studies using the hand-held calculator, but we shall be examining use of the microcomputer in various areas of the curriculum. It should be noted that the student population of the Laboratory School is representative of the general population of the State. Therefore, the results of our research are applicable to the general student population of the public schools of the State of Florida.

J. B. Hodges, Director
P. K. Yonge Laboratory School
and Professor of Education

Kindergarten children used calculators along with manipulatives in math activities.

CHAPTER I

PURPOSE, RATIONALE, AND REVIEW OF THE LITERATURE

Purpose

The purpose of this study was to investigate the effects of the use of hand-held calculators on problem-solving and computational skills of elementary school students and to consider resulting implications for curriculum change. Evaluation focused on achievement in problem solving, computational skills, and number concepts of kindergarten, second grade, and fourth grade students.

Rationale and Review of the Literature

The declining cost of the hand-held calculator has contributed to the rapid increase in its use by students as well as by adults. Some students, even at the elementary school level, are bringing their own calculators to school. In the immediate future, as schools find it financially feasible to provide calculators for students, classroom sets of hand-held calculators may become as commonplace as sets of textbooks.

The 1977 Report of the Conference on Needed Research and Development on Hand-Held Calculators in School Mathematics, sponsored by the National Science Foundation (NSF) and the National Institute of Education (NIE), refers to predictions that, by 1980, the number of hand-held calculators in use in the United States will approximate the number of refrigerators, or the number of television sets, or the number of automobiles in the country. The widespread use of calculating machines and computers in the world outside of schools leads to speculation that the school classroom is one of the few places where paper-and-pencil computation is still required.

Because of the decrease in cost and the availability of hand-held calculators, it behooves mathematics educators to seriously consider the role of calculators in the teaching of mathematics. The National Science Foundation, the National Institute of Education, the National Council of Teachers of Mathematics, and the National Advisory Committee on Mathematics Education have recognized the potential use of calculators as aids to educators, have encouraged their use in classrooms, and have called for studies to determine appropriate use in classrooms and the effects on student attitude and achievement. In September 1974, about a year after

hand-held calculators appeared on the market in significant numbers, the National Council of Teachers of Mathematics (NCTM) approved the following position statement:

> With the decrease in cost of the minicalculator, its accessibility to students at all levels is increasing rapidly. Mathematics teachers should recognize its potential contribution as a valuable instructional aid. In the classroom, the minicalculator should be used in imaginative ways to reinforce learning and to motivate learners as they become proficient in mathematics. (3, p. 468)

The Board of Directors of NCTM has adopted the following goal for the Council:

> To encourage the development and evaluation of curriculum and instructional materials incorporating the use of the hand-held calculator and other computing devices. (3, p. 468)

In response to this call to determine appropriate use of calculators and to develop and evaluate curriculum materials, many educators have used calculators in their classrooms and conducted studies to measure the effects. Suydam (7), in reviewing the state-of-the-art, cited a survey conducted by Weiss (8) in 1979. This survey of a random sample of 1177 schools, representative of the total school population in the United States, showed that 6% of the teachers in the kindergarten through third grade and 14% of the teachers in grades four through six used calculators in their mathematics classes. However, 15% of the kindergarten through third grade teachers and 39% of the teachers in grades four through six said that calculators were needed but not available. Twenty-eight per cent (28%) of the schools had calculators in grades kindergarten through three, while 36% of the schools had them in grades four through six.

Suydam (7) also reported that almost 100 studies of the effects of calculator use have been conducted during the past four or five years. In all but a few cases, the achievement scores were as high or higher when calculators were used for instruction than when they were not used. These data provide strong support for the conclusion that use by students does not seem to be detrimental to mathematics achievement.

Wilson, Lott, and Kuster (10) studied the effects of calculator use with traditional texts on the achievement of students in grades three through six and found no significant difference in achievement between the experimental and control groups. In a study of classroom use of calculators in grades four through six, Capoferi, Winowski, and Schram (1) found slightly larger gains in achievement were made by the calculator groups than by the groups not using calculators. Nebel (4) reported a higher level of performance on the measure of achievement in computation for a group of fifth grade students using calculators in their classrooms than those not using calculators.

Wheatley, et al. (9), in a study conducted in five schools involving fifty teachers of 1500 students in grades two through six, found no significant difference in the test scores between calculator and no-calculator classes. These investigators found no basis for the fear

expressed by administrators, teachers, and parents that children will not learn basic facts and mathematical concepts if calculators are used. On the contrary, the investigators were convinced that calculators can have a positive effect on mathematics learning in the elementary school.

Second grade students used calculators two or three times a week.

In kindergarten, teachers worked with small groups of children using calculators.

CHAPTER II

DESCRIPTION OF THE PROGRAM

The ten-month study at P. K. Yonge, started in September 1978, involved two classes each of kindergarten, second grade, and fourth grade students with approximately thirty students in each class. Fifteen hand-held calculators (Casio AL-8S) were provided for each of the six classrooms, making the ratio of calculators to students about 1 to 2. This calculator has per cent, square root, common fraction, memory, and date functions, as well as the four basic functions. The kindergarten, second grade, and fourth grade classes were designated experimental groups, and grades one, three, and five were named control groups. The control groups were tested in May 1978, when they were kindergarten, second grade, and fourth grade classes. The same instrument, the mathematics section of the 1971 edition of the Metropolitan Achievement Test Form F, was administered to the experimental groups in May 1979.

In a two-week workshop conducted by the project director in the summer of 1978, the six teachers of the experimental groups became acquainted with current literature and attitudes on calculator use. They experienced "hands on" calculator activities and considered ways to enhance the elementary school mathematics curriculum through calculator use. There was also time for teachers to create calculator materials for classroom use for the next year.

During the year, the project director provided direction and suggestions to teachers, but teachers made decisions about specific activities and how frequently calculators were used in their programs. Frequent classroom observations were made by the project director, and follow-up discussions with the teacher were held whenever time permitted. Sharing and evaluation meetings of grade level teachers and of the entire group of six experimental teachers were held periodically.

Problems with maintenance and security of calculators were almost nonexistent. Teachers and students took ordinary but responsible precautions in handling with care, storing securely, and conserving batteries. In some classrooms, children were responsible for distributing calculators, putting them away, and replacing batteries. During the year no damage from student abuse was detected. Of the ninety calculators used by six classes, one malfunctioned and two were lost. Less than $50.00 was spent replacing batteries during the year.

Older children seemed to need less instruction in how to use calculators than younger children. Second grade and fourth grade children were given no specific instruction in how to compute with calculators unless they needed it. Very few asked for assistance. Students were

puzzled at first because "+", "-", "X", "÷", and "=" did not appear in the display when pressed. A few children were curious about keys with unfamiliar symbols (√, %, etc.), but they were satisfied with a brief explanation or being told they would learn about these symbols later.

Kindergarten children needed more instruction in how to use calculators. Initially, some children had trouble with motor coordination and pressed a key two or three times instead of once. Instructions to press "2" would result in "22" or "222" in the display. Kindergarten children also needed reminders to clear their calculators if they made a mistake or wanted to "erase" a number and enter a different one. After a few days, these problems no longer existed. Difficulty with entering four consecutive symbols ("2 + 3 =") also disappeared after a few days.

Fifteen calculators were a sufficient number per class. In kindergarten, teachers usually worked with a group of eight to ten children, and each child had a calculator. In the second and fourth grade classes, usually some students were working on math while others were engaged in some other activity. Most of the time each child had a calculator, but even when the entire class was working on math, there were no serious problems with students' sharing calculators.

Calculator activities and the frequency of their use varied from classroom to classroom. On the average, the frequency of use was two or three times per week.

Many number recognition and counting activities were used with calculators in kindergarten. Kindergarten teachers were very enthusiastic about calculator use because it enabled children to work with numbers and number concepts even before they could write.

A typical lesson at the second grade level included some problems for which the student could choose to use or not to use a calculator and some problems for which he was instructed not to use a calculator. Most students did not complain when instructed to do their work without calculators. They tended to use calculators for more difficult computation only and could usually determine when it was easier and faster not to use calculators. In one classroom, calculator activities were an option during "choice time", when a variety of activities, many of which were not mathematical in nature, were available to students.

Many of the activities at the fourth grade level involved problem solving and identifying several different procedures for solving the same problem. These activities were aimed toward enabling students to concentrate on the problem-solving process by allowing them to use calculators for burdensome and time-consuming computations.

Activities for each grade level are described in detail in Appendixes A, B, and C.

In general, the teachers involved in the study had positive feelings about calculator use. All six have indicated that they want to continue using calculators in their math programs next year.

Second grade children used calculators for group activities and for individual work.

CHAPTER III

ANALYSIS OF DATA

Student Achievement

This investigation examined differences in achievement test scores in mathematics of the experimental and control groups of children. The control group was composed of the kindergarten, second grade, and fourth grade classes in 1977-1978, and the experimental group was the 1978-1979 kindergarten, second grade, and fourth grade classes. The experimental group used calculators in classrooms; the control group did not. Neither group used calculators on the testing instrument, the mathematics part of the 1971 edition of the Metropolitan Achievement Test Form F (MAT).

For grades two and four, the mathematics part of the MAT was made up of three sections: Mathematics Computation, Mathematics Concepts, and Problem Solving. For kindergarten, there was only one section. The control group of 49 kindergarten children, 59 second grade children, and 56 fourth grade children was tested in May 1978. In May 1979, the experimental group, composed of 51 kindergarten, 52 second grade, and 58 fourth grade children, was tested.

The study was designed to investigate three questions:

1. What effect, if any, does the classroom use of hand-held calculators have on mathematics achievement of kindergarten children?

2. What effect, if any, does the classroom use of hand-held calculators have on mathematics achievement of second grade children?

3. What effect, if any, does the classroom use of hand-held calculators have on mathematics achievement of fourth grade children?

Each question was analyzed using an analysis of variance (ANOVA). The first question investigated differences between achievement scores of experimental and control groups of kindergarten children. The F-value was 4.342 with 1 and 98 degrees of freedom (see Table 1). This F-value was significant at the .04 level. Hence, there appears to be a difference between the experimental and control groups at the kindergarten level. The mean score for the experimental group was 26.27 and for the control group, 23.94. Therefore, it appears that the experimental group scored significantly higher than the control group in kindergarten.

TABLE 1

Analysis of Variance Results for
the Numbers of Scores of the MAT Between
Experimental and Control Groups in Kindergarten

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Treatment (Experimental vs Control)	136.337	1	136.337	4.342	0.040
Residual (or Error)	3076.963	98	31.398		
Total	3213.300	99	32.458		

The second question concerned differences between achievement scores of experimental and control groups of children in second grade. For Mathematics Computation, the F-value was 0.359 with 1 and 109 degrees of freedom (see Table 2). This F-value was not significant at the .05 level. Therefore, it appears that there is no significant difference between the experimental and control groups on Mathematics Computation at the second grade level. The mean score of the experimental group was 20.942 and for the control group, 21.797. For Mathematics Concepts, the F-value was 0.123 with 1 and 109 degrees of freedom. This F-value was not significant at the .05 level. Therefore, it appears that there is no difference between the experimental and control groups on Mathematics Concepts at the second grade level. The mean score of the experimental group was 26.231 and for the control group, 26.763. For Problem Solving, the F-value was not significant at the .05 level. Therefore, it appears that there is no significant difference between experimental and control groups in Problem Solving in second grade. The mean score of the experimental group was 23.250 and for the control group, 22.644.

TABLE 2

Analysis of Variance Results for
the Numbers of Scores on the MAT Between
Experimental and Control Groups in Second Grade

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Mathematics Computation					
Treatment (Experimental vs Control)	20.172	1	20.172	0.359	0.551
Residual (or Error)	6132.328	109	56.260		
Total	6152.504	110	55.932		
Mathematics Concepts					
Treatment (Experimental vs Control)	7.821	1	7.821	0.123	0.726
Residual (or Error)	6915.797	109	63.448		
Total	6923.621	110	62.942		
Problem Solving					
Treatment (Experimental vs Control)	10.148	1	10.148	0.149	0.700
Residual (or Error)	7403.164	109	67.919		
Total	7413.313	110	67.394		

The third question examined differences between achievement scores of experimental and control groups of children in fourth grade. For Mathematics Computation, the F-value was 0.177 with 1 and 112 degrees of freedom (see Table 3). This F-value was not significant at the .05 level. Therefore, it appears that there is no significant difference between the experimental and control groups on Mathematics Computation at the fourth grade level. The mean score of the experimental group was 25.983 and for the control group, 26.679. For Mathematics Concepts, the F-value was 2.228 with 1 and 112 degrees of freedom. This F-value was not significant at the .05 level. Therefore, it appears that there is no difference between the experimental and control groups on Mathematics Concepts at the fourth grade level. The mean score of the experimental group was 26.362 and for the control group, 25.161. For Problem Solving, the F-value was 0.212 with 1 and 112 degrees of freedom. This F-value was not significant at the .05 level. Therefore, it appears that there is no significant difference between experimental and control groups in Problem Solving in fourth grade. The mean score of the experimental group was 24.741 and for the control group, 24.054.

TABLE 3

Analysis of Variance Results for
the Numbers of Scores of the MAT Between
Experimental and Control Groups in Fourth Grade

Source of Variation	Sum of Squares	df	Mean Square	F	Significance of F
Mathematics Computation					
Treatment (Experimental vs Control)	13.794	1	13.794	0.177	0.675
Residual (or Error)	8745.063	112	78.081		
Total	8758.859	113	77.512		
Mathematics Concepts					
Treatment (Experimental vs Control)	138.067	1	138.067	2.228	0.138
Residual (or Error)	6940.820	112	61.972		
Total	7078.891	113	62.645		
Problem Solving					
Treatment (Experimental vs Control)	13.479	1	13.479	0.212	0.646
Residual (or Error)	7115.852	112	63.534		
Total	7129.332	113			

While there was only one significant difference determined through the ANOVA results, it was noteworthy to investigate the mean scores. Table 4 provides mean values, mean differences, standard deviations, and N's for each mathematical score by treatment group and grade. As shown in the table, the difference in the mean scores on Mathematics Concepts for grade four is much more extreme than any of the other non-significant differences. This tends to make the researcher believe that further research might show a significant difference between the two groups in favor of the experimental group.

TABLE 4

Means, Mean Differences, Standard Deviations and N's for the Metropolitan Achievement Test Scores in Mathematics for the Experimental and Control Groups by Grade Levels

Section of MAT	Grade and Treatment Group	Mean	Mean Difference	SD	N
Mathematics Computation	Kindergarten				
	Experimental	26.275	2.336	5.307	51
	Control	23.939		5.896	49
	Grade 2				
	Experimental	20.942	-0.855	7.752	52
	Control	21.797		7.272	59
	Grade 4				
	Experimental	25.983	-0.696	8.872	58
	Control	26.679		8.799	56
Mathematics Concepts	Grade 2				
	Experimental	26.231	-0.532	8.917	52
	Control	26.763		7.023	59
	Grade 4				
	Experimental	27.362	2.201	8.431	58
	Control	25.161		7.248	56
Problem Solving	Grade 2				
	Experimental	23.250	0.606	8.584	52
	Control	22.644		7.928	59
	Grade 4				
	Experimental	24.741	0.687	8.211	58
	Control	24.054		7.714	56

The data seem to indicate that there is no significant difference in achievement between the experimental and control groups in second and fourth grades. This seems to indicate that calculator use has no detrimental effect on mathematics achievement at these grade levels. There is certainly need for further study. Even though this was a year-long investigation, it is still short-term when compared to the entire school life of the subjects. An investigation of several years' duration is needed to study the effects of calculator use on second and fourth grade students.

The data on achievement in mathematics at the kindergarten level are very interesting. There seems to be a significant difference between the achievement of the experimental and control groups in favor of the experimental group. This may indicate that calculator use in kindergarten has a positive effect on achievement in mathematics. Further investigation is certainly needed in this area. If kindergarten children do achieve better in mathematics when they use calculators, educators need to know and to act accordingly. Again, long-term studies are needed.

P. K. Yonge Laboratory School will continue to investigate the effects of calculator use on the mathematics achievement of elementary school children. In the 1979-1980 school year, calculators will be used not only in the classes which composed the experimental group in this study but in all elementary classrooms, kindergarten through fifth grade. Careful observation and evaluation of the results will be made.

Parent Attitudes

An attempt was made to assess changes in parents' attitudes toward calculator use in instruction. For this purpose the researcher constructed a questionnaire (see Appendix D) which was sent to parents of children in all grades from kindergarten through fifth grade in August 1978 to determine attitudes and opinions of parents toward calculator use. Questionnaires were mailed to 281 families. It is interesting to note that 90% of these were completed and returned.

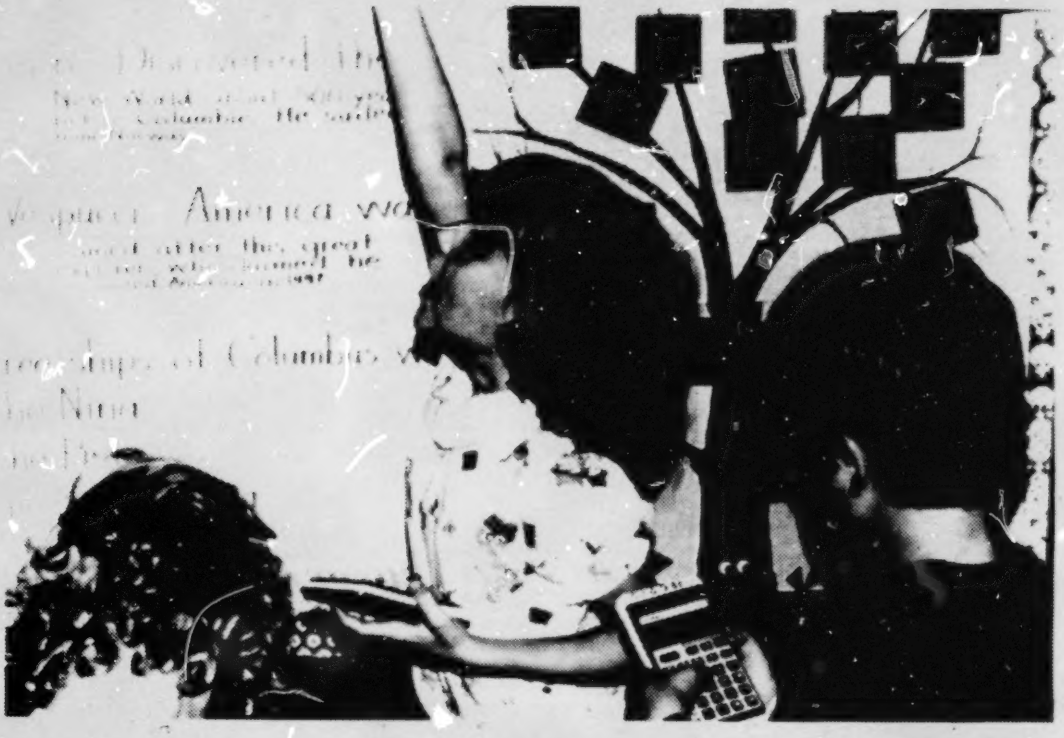
The same questionnaires were sent to the same group of parents in May, 1979. The rate of return was 74%. The pre- and posttests were separated into two groups, one from parents of the control students and the other from parents of experimental students, for comparison of responses. However, the comparison did not show any noteworthy difference between the two groups in change in responses from pretest to posttest.

Item percentages of total respondents are presented in the appendixes. Appendix E presents the pretest and posttest results for the experimental group. Appendix F presents the pretest and posttest results for the control group, and pretest and posttest results for the total group are in Appendix G.

In general, for the total group, percentages of positive responses increased from pre- to posttest on items which dealt with ownership of calculators and use by parents and children, attitude toward calculator use by elementary school students on homework, attitude toward classroom use of calculators at all grade levels, and attitude toward use by high school students on tests.

Several interesting observations can be made about the results of the questionnaire. First, the 90% rate of return on the pretest was excellent. The decrease to a 74% rate of return on the posttest may be explained in part by the fact that a stamped envelope was provided for families to mail their responses to the school on the pretest, but responses were returned to the school by children on the posttest.

Approximately 220 households responded to the questionnaire. Responses indicate that more than 90% of these households have calculators, and about one-half of the fathers and more than one-third of the mothers use calculators in their work. Calculators are used more than twice a week by about 60% of the parents. More than half of the respondents think high school students should be allowed to use calculators on homework assignments, and almost half think that high school students should be allowed to use calculators on tests. About 80% of the respondents favor the regulated use of calculators as instructional aids in the classroom at all grade levels; but fewer than 15% favor unrestricted calculator use in the classroom in grades one through eight, and about 30% favor its unrestricted use in grades nine through twelve.



Calculators were used in second grade for drill in basic facts.

CHAPTER IV

IMPLICATIONS FOR THE FUTURE

The prevalence of hand-held calculators in all segments of our society at a price which is within the reach of most school budgets is a strong factor influencing educators in the consideration of classroom use of calculators. Even though this is an important factor, there is another one of equal or greater importance: The effect of classroom use of calculators on the child's learning of mathematics. Because of these two factors, it behooves mathematics educators to seriously consider the possibilities of the use of calculators in classrooms and to investigate carefully the effects of their use. The study at P. K. Yonge was conducted in response to this need.

Although several studies of the effects of calculator use on mathematics achievement have been done, many of them have been short-term studies, concerned with a specific concept or topic. Additional investigations are needed, especially at the elementary school level, to study long-term effects and to consider the implications for changes in the elementary school mathematics curriculum. As was stated earlier, P. K. Yonge Laboratory School will attempt to provide such a study. Not only will the experimental classes of the 1978-1979 study continue to use calculators next year, but calculators will also be used in the other elementary classrooms. This will allow an investigation of the effects of calculator use on achievement at all grade levels, kindergarten through fifth grade. Achievement of these students can also be monitored as they progress through school to the twelfth grade.

The effect of calculator use on children's attitudes toward mathematics is another aspect to be investigated. If a large segment of the population suffers from math anxiety, which may start in early childhood, then it is important to know if calculator use can help to alleviate the fear that some children seem to develop toward mathematics. Perhaps a child who has experienced failure because of difficulty with computation can experience success and feel good about himself and mathematics if he uses a calculator. This needs to be determined. If a child's feelings of inferiority and failure can be overcome, the approximate $10 expense for a calculator has been spent wisely. In the P. K. Yonge study, instruments to measure the attitude toward mathematics of both students and teachers will be administered at the beginning and again at the end of the year to obtain data for determining effects of calculator use on mathematics attitude.

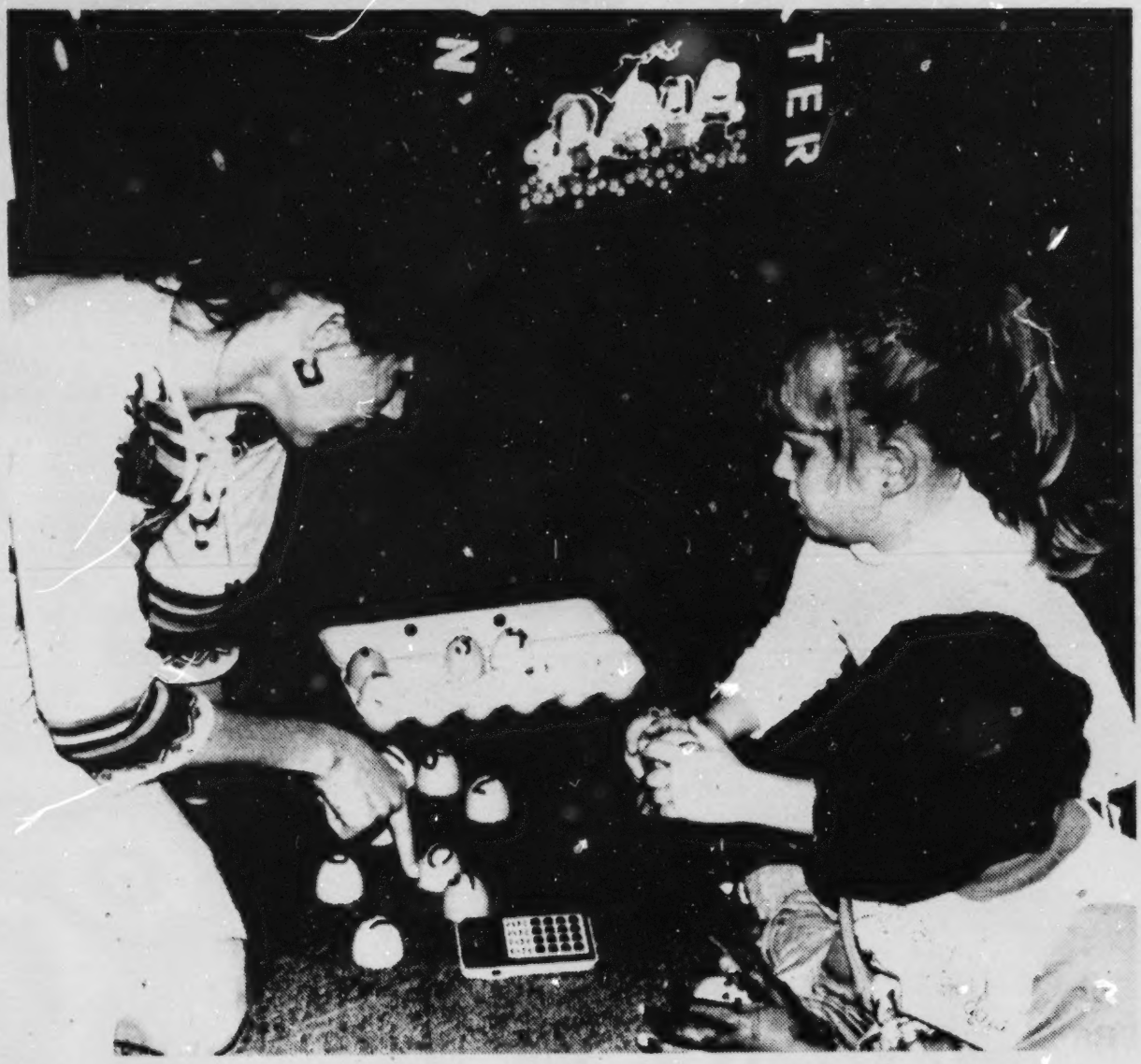
There is a need to make the mathematics curriculum more functional by emphasizing everyday problems that children are encountering now and will encounter in the near future. These problems should be meaningful to a child at a given grade level because they exist in his real world.

This functional, problem-solving aspect of mathematics has not been emphasized in the past as much as computation. The results of the State Functional Literacy Test show that many students are not competent in applying mathematics to real life situations. Perhaps a program which focuses more on solving meaningful problems in mathematics than on the computational algorithms would produce more successful students. Calculators would certainly be useful in such a program in reducing the time and energy spent in computation. The elementary mathematics program at P. K. Yonge next year will focus on applying mathematics to problems in the real world of the child.

A discussion of calculator use in elementary school must eventually address the issue of how much paper-and-pencil computation to require of students and how much computation with a calculator to allow. There are conflicting opinions as to the importance of teaching computational algorithms. Giese (2, p. 57) states, ". . . students should know the basic algorithms before calculators are used. It is important for them to know what the calculator is doing, that it is not just a magical box producing numbers." Wheatley, et al. (9, p. 21) countered that, "Computational skill has no value in itself; it is important only as it is useful in problem solving." Shumway (6, p. 9) makes this recommendation, "Reduce work with paper-and-pencil algorithms to a brief familiarity with the simplest computations. Assume all computations taking more than ten seconds should be done with a calculator and such paper-and-pencil computations serve no needed role in the mathematics curriculum."

Although opinions vary about de-emphasizing computational algorithms, there is agreement that many students cannot perform basic computations, even though computational skills were strongly emphasized in the curriculum. Again, the results of the State Functional Literacy Test indicate that computational skill deficiencies exist.

Since the teaching methods used in the past have not been successful for a significant number of students, questions must be raised, and new methods and aids must be sought. Perhaps a curriculum which emphasizes the meaning of an operation and when to apply it, rather than the algorithm, could provide more meaningful and successful experiences in mathematics for students. Now that hand-held calculators are available, it is possible to implement that kind of curriculum.



Calculators were used with many counting activities in Kindergarten.

APPENDIXES

APPENDIX A

MATHEMATICS PROGRAM OUTLINE AND SUGGESTED CALCULATOR ACTIVITIES FOR KINDERGARTEN

Hand-held calculators can be used successfully at the kindergarten level to supplement the other activities, manipulatives, and teaching aids which are effective in teaching math concepts and skills. The following pages present some of the concepts and skills found in most kindergarten mathematics programs and suggested calculator activities to aid in teaching these concepts and skills. These are not necessarily listed in the order in which they are taught.

The calculator activities which are described were used in two kindergarten classrooms of twenty-seven students each. A teacher worked with a group of eight to ten children, with a calculator provided for each child. The responsible use and care of calculators was emphasized to the children. Two other initial instructions seemed to be especially beneficial to the children. They were: (1) Let calculators remain flat on the table when in use, and (2) Press calculator keys with the index finger of the right hand if right-handed or the left hand if left-handed.

Concepts and Skills	Calculator Activities
I. Number Recognition: Recognize and identify the numerals 0-9. Associate the name of the number with numbers 0-20. Associate concept of number (from counting) with numeral. Associate name of number (word) with numeral.	I. 1. Give each child a calculator. Ask, "How old are you? Press that key on your calculator and let me see the number." Additional questions: "How many sisters do you have?" "How many dogs do you have?" "How many boys are in this group?", etc. Initially, children may need to be reminded to clear their calculators after answering each question. 2. Instruct the children to press the calculator key with the same number as the number of cubes placed on the table by the teacher. Place one cube on the table, and "1" should be pressed on calculators. Place two cubes on the table and "2" should be pressed.

Concepts and Skills

Calculator Activities

Continue in like manner to nine, ten, or whatever largest number is appropriate. Entering two digit numbers in calculators would need to be discussed. The activity could be varied by first placing seven cubes on the table, then three cubes; i.e., the number of cubes in consecutive questions would not be in numerical order.

3. Use flash cards with the numerals 0-9 written on them. Show a card and ask children to press that calculator key. Clear calculators. Repeat. Cards should be shown in numerical order, and they should also be shown not in sequence. Variation: Show cards in numerical order and ask children to enter numbers without clearing calculators between entries. The sequence 1 2 3 4 5 6 7 8 will appear in the display, and calculators must be cleared before 9 can be entered.

4. Use flash cards with the words one to ten written on them. Show a card and ask children to press that calculator key. Cards should be shown in sequence and also not in sequence.

5. Prepare 5" x 8" index cards so that each child can have a set of eight to ten cards with pictures of sets of objects on the front of each card and the number of objects in the set written as a numeral on the back. Pictures can be cut from an old book and glued to the cards, and cards can be laminated.

   Instructions are to count the number of objects in the picture, enter that number in the calculator, and turn the card over to see if the numeral on the back is the same as the one on the calculator display. If the numerals are the same, clear the calculator and go to the next card. When a child finishes his set of cards, he may exchange cards with someone else who has finished.

Concepts and Skills

Calculator Activities

6. This activity emphasizes the location of the number keys on the calculator as well as listening skills, number recognition, and number sequencing. Ask children to press the three keys in the order named.

   Press 1, 2, 3. Clear. ┐
   Press 4, 5, 6. Clear. │ Horizontal
   Press 7, 8, 9. Clear. ┘

   Press 1, 4, 7. Clear. ┐
   Press 2, 5, 8. Clear. │ Vertical
   Press 3, 6, 9. Clear. ┘

   Press 1, 5, 9. Clear. ┐ Diagonal
   Press 3, 5, 7. Clear. ┘

   This activity can be repeated as many times as seems appropriate. The vertical sequencing could be given from top to bottom, e.g., 7, 4, 1. The horizontal sequencing should always be from left to right to reinforce the direction of reading.

7. Give each child an egg carton in which the compartments are numbered on the inside 1-12, a calculator, and a plastic bag containing twelve colored plastic eggs which are separated into halves. In each bag twelve of the halves are numbered 1-12, and the other halves have the corresponding number of dots. The halves which correspond, numeral to number of dots, are not the same color.

   Instruct each child to separate the egg halves into two groups, so that one group has dots and the other group has numbers. Then, pick up a half with dots on it, count the dots, and enter that number on the calculator. Next, find the half with the number which is displayed on the calculator and put the halves together. Place the egg in the carton in the compartment which has that number. Continue until all eggs are in the carton.

Concepts and Skills	Calculator Activities
II. Counting: Count up to ten objects	II. 1. Give each child a set of cubes, a white card 8-1/2" x 11", and a calculator. Instruct the group to place three cubes on the card. Then place another set of three cubes on the card. Press the calculator key which has that number. Then press the calculator key which corresponds to the total number of cubes (found by counting) on the card. Repeat, using other numbers. 2. Activities numbered 2, 5, and 7 listed under Number Recognition also involve counting.
III. Order of Sequencing of Numbers: Number after 2, number before 2, etc.	1. Give each child a set of five squares, 1-1/2 inches on a side, with the numbers 1-5 written on them. Instruct the children to arrange these cards in order, smallest to largest, from left to right. When the entire group has the correct sequence, ask the children to enter the numbers in their calculators. The display should show 1 2 3 4 5. Then give each child another set of squares numbered 6-10, and instruct the group to continue the sequence so that the squares are ordered 1-10. Some children will need help with entering 10 in calculators. Instruct the children to look at the sequence of squares (1-10) and enter in their calculators the number before 2, the number before 3, the number after 2, the number after 3, etc., until the first eight consecutive numbers are entered. Clear calculators, and give appropriate instructions for entering 9 and 10.
IV. Combinations of Groups: Addition Subtraction	IV. 1. Ask, "How many girls are in our group?" Count aloud to find the answer. Also count to determine the number of boys in the group. Then ask, "What is the total number of people in our group?" Count to determine the answer.

Concepts and Skills

Calculator Activities

Then instruct the children how to use their calculators to combine the total number in the group. If there are five girls and three boys in the group, they should press the keys 5 + 3 = . Point out that the "8" displayed on their calculators is the same answer the group obtained by counting.

Initially, children may have difficulty pressing four keys in sequence. One difficulty is that when a child makes a mistake, he must clear his calculator and start again. Children may be confused that = and + do not appear in the display when the keys are pressed.

Similar exercises can be created from other questions about numbers of people and objects in the room.

2. The teacher needs cubes of various colors for this activity. Place three red cubes on the table and ask the children, "How many red cubes are there?" Then place two blue cubes on the table, and ask, "How many blue cubes are there?" and "How many red and blue cubes are there?" Answers should be determined by counting.

   The teacher then instructs each child to find the total number of red and blue cubes on his calculator by pressing the key for the number of red cubes, pressing "+", pressing the key for the number of blue cubes, and pressing "=". The number in the calculator display should be the same as the number obtained by counting.

   Obviously, many different number combinations can be used.

3. Draw a face on a paper plate, making the eyes and mouth large enough to place sets of cubes in them.

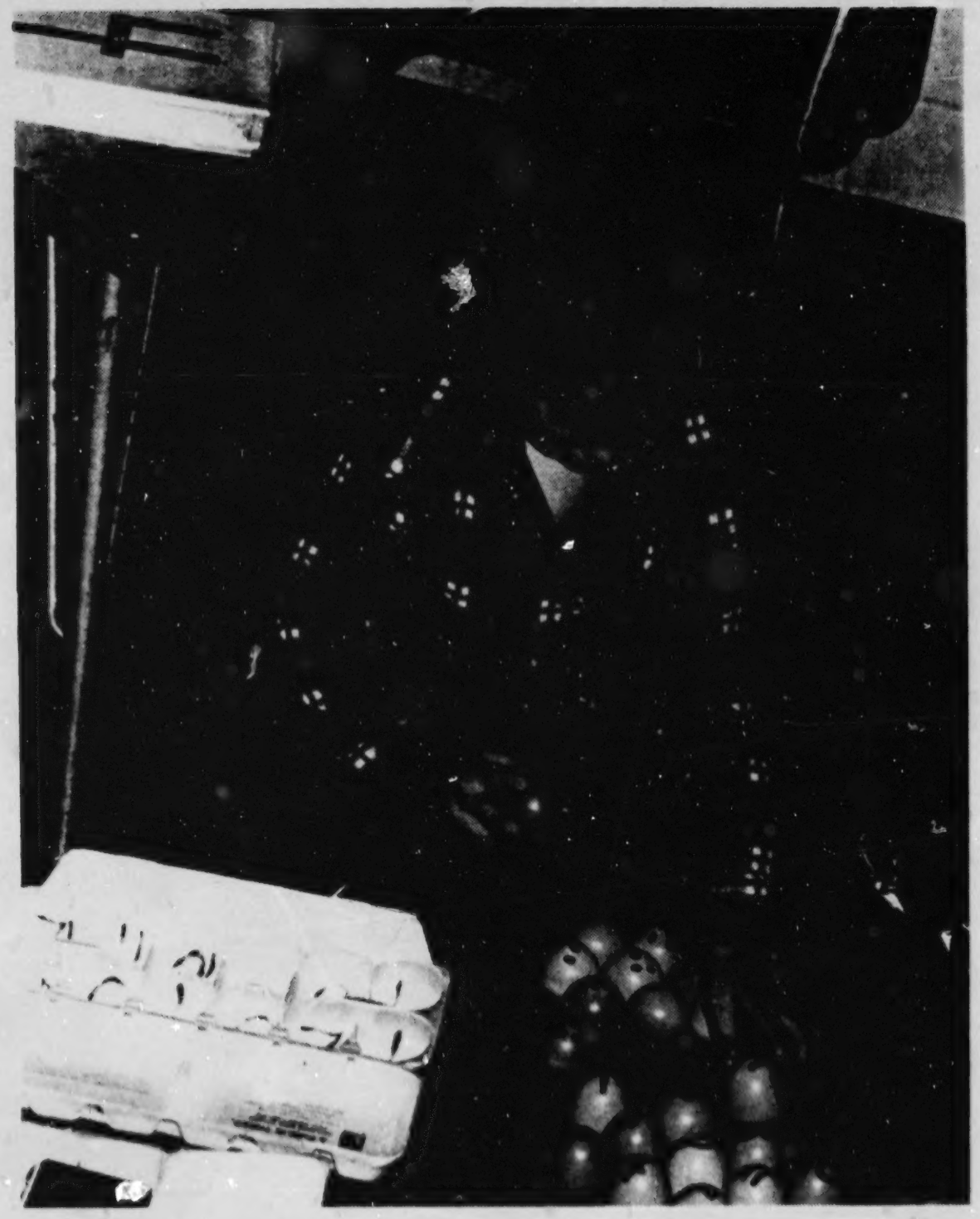
Concepts and Skills

Calculator Activities

Give each child a plate, a set of cubes, and a calculator. For the problem 6 + 3, a child places six cubes in the left eye and three cubes in the right eye. The child counts to determine the total of nine and places nine cubes in the mouth. Then the child moves the cubes from the eyes and matches them with the cubes in the mouth to see if the number of cubes in the mouth is correct. Finally, he/she works the problem on the calculator to see if the answers agree.

4. After an Easter egg hunt, each child made a bar graph showing how many eggs he/she and some of his friends found. Each graph showed the number of eggs found by five or six children. Children determined from the graphs who found the most eggs (in that group), who found the fewest, who found more than three eggs, etc. They used calculators to find the total number of eggs found by two children. Answers determined from the graph and calculator answers were compared.

Kindergarten children used calculators in number recognition exercises.



Plastic eggs and calculators were used to help Kindergarten children learn to count and to recognize numbers.

APPENDIX B

CALCULATOR ACTIVITIES FOR SECOND GRADE

The calculator activities which are described were used in two second grade classrooms of approximately twenty-seven students each. Not all students worked on math at the same time, which enabled each student working math to have a calculator.

Concepts and Skills	Calculator Activities
I. Numeration and Counting	I. 1. Give orally any number smaller than 200 to students to be entered in the calculator display.
	2. Instruct students to count by 1's to 500 on their calculator.
	3. Ask students to count by 2's to 100 on their calculators.
	4. Ask students to count by 3's (also by 5's, 10's) to 100 on their calculators.
	5. Vary the counting activities by beginning with an odd number and counting by 2's. Also begin with an even number and count by 3's.
	6. Given a number, count backwards by 1's (also by 2's).
	7. Give students a list of word names of several numbers. Instruct students to enter each number in their calculators and to find the sum of the numbers. The correct sum should be provided in numerals as a check for students.
	8. For an activity on place value, give students a table similar to the one below, and ask students to use calculators to help find the number.

Concepts and Skills	Calculator Activities

hundreds	tens	ones
	3	9
2	14	3
3	0	16

etc.

II. Computation

II. 1. Prepare a worksheet of problems involving any of the four operations. The answer to each problem should be a word when the calculator is turned upside down. Appropriate questions can be asked for the word answers. Example: What is worn on the foot? For the answer, add 2715 + 330 on the calculator, then turn your calculator upside down.

2. Prepare a worksheet of problems involving any of the four operations. Include answers for all the problems, but provide incorrect answers for some of the problems. Ask students to correct the problems which have incorrect answers.

3. Prepare a worksheet of problems involving any of the four operations. Omit some numerals in the problem and answer. Instruct students to find the missing numerals. It is important to discuss the different processes which students use. Examples:

$$\begin{array}{r} 3\,\square \\ \square\,8 \\ +\ 2\ 7 \\ \hline 1\ 1\ 1 \end{array} \qquad \begin{array}{r} 3\ 1\square\ 7 \\ -\ 1\square\ 8\ 3 \\ \hline 1\ 1\ 6\square \end{array}$$

4. For drill on basic facts, give two students a calculator and a list of some basic facts. Instruct one student to read the problem (9 + 8) aloud. The other student should enter the problem on the calculator as he hears it. The first student tries to give the answer before his partner gets the answer on the calculator. Students can change roles.

Concepts and Skills	Calculator Activities
III. Problem Solving	III. 1. Find the total cost of aritcles "bought" from a newspaper ad.
	2. Ask a local restaurant to donate copies of their menu. Ask students to order a meal for their families and find the total cost.
	3. Many problems involving long computation and large numbers can be prepared. Examples: How many seconds old are you? How many times does your heart beat in a year? Count one count per second. How long will it take to count to one million? How many lunches will be served in your school cafeteria in a year based on the number served daily?

Second grade students used calculators to help with the computation in word problems.

APPENDIX C

CALCULATOR ACTIVITIES FOR FOURTH GRADE

In two fourth grade classes of approximately thirty students each, calculator activities included the expected activities of checking computation and using calculators for the computation in solving work problems. Also, the activities in Appendix B, designed for second grade, were used in fourth grade with modifications to make them appropriate for that grade level. The fourth grade activities described below will not include the kinds listed above, but will include additional types of problems. The problems listed are intended to be suggestive of other problems and activities which are thought-provoking and meaningful to fourth grade students and which necessitate research and discussion of process on the part of the student.

Each student had a calculator since the entire class did not work on math at the same time.

Activities

1. Ask students to find the answer to a multiplication problem on calculators and to prove that the answer is correct. Discuss procedures used by different students.

2. Find the largest product possible using 0, 1, 2, 3, and 4 exactly one time each to form numbers.

3. After multiplying many two and three digit numbers by 11 and observing the results, write a rule for multiplying by 11.

4. If you spend $5 per minute, how long would it take to spend one million dollars?

5. Every time a baseball player hits a home run, he runs at least 360 feet. If Willie Mays hit 660 home runs, how many miles did he run?

6. Count by .1 beginning with .1 and ending with 1.2. How many times did you add .1?

7. Count by .01 beginning with .91 and ending with 1.1. How many times did you add .01?

8. Use a calendar, draw a square (3 x 3 or 4 x 4, etc.), and investigate relationships among the numbers and among sums of some of the numbers. Do the same with a hundreds chart.

9. Cards are numbered consecutively beginning with 101 and ending with 202. If the sum of the digits on a card is 15, the card is a winning card. How many winning cards are in the group?

10. Many problems involving data collection, analysis, and presentation of the data can relate to sports teams and players. Averages, percentages, and graphs of local and national teams and players can be presented by students.

11. The school plant and family is a good problem source.

    (a) What fractional part of our class members has a dog for a pet?

    (b) How many classrooms are in our school? How many square yards of carpet would it take to carpet all the classrooms?

    (c) What part of our faculty is male?

Fourth grade students sometimes worked in pairs, sharing a calculator.

The problem-solving process was emphasized in the fourth grade, where students used calculators for time-consuming computations.

APPENDIX D

QUESTIONNAIRE

Place an X in the appropriate blank. NA means the question is not applicable to your household.

	Yes	No	NA
1. Does someone in your household own a hand-held calculator?			
2. Does the father in your household use a hand-held calculator in his work?			
3. Does the mother in your household use a hand-held calculator in work outside the home?			
4. Is the calculator used by either or both parents when shopping?			
5. Is the calculator used on the average more than two times per week by either parent in your household?			
6. Is the calculator use on the average more than two times per week by any child in your household?			
7. Do elementary school students in your household use a calculator on homework assignments?			
8. Do middle school students in your household use a calculator on homework assignments?			
9. Do high school students in your household use a calculator on homework assignments?			
10. Do you think elementary school students should be allowed to use a calculator on homework assignments?			
11. Do you think middle school students should be allowed to use a calculator on homework assignments?			
12. Do you think high school students should be allowed to use a calculator on homework assignments?			

	Yes	No	NA
13. Are you in favor of the unrestricted use of calculators in the classroom by elementary students?	_____	_____	_____
14. Are you in favor of the unrestricted use of calculators in the classroom by middle school students?	_____	_____	_____
15. Are you in favor of the unrestricted use of calculators in the classroom by high school students?	_____	_____	_____
16. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by elementary school students?	_____	_____	_____
17. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by middle school students?	_____	_____	_____
18. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by high school students?	_____	_____	_____
19. Do you think elementary school students should be allowed to use a calculator on classroom tests?	_____	_____	_____
20. Do you think middle school students should be allowed to use a calculator on classroom tests?	_____	_____	_____
21. Do you think high school students should be allowed to use a calculator on classroom tests?	_____	_____	_____

Grades in which you will have children at P. K. Yonge next year _____

_____

_____

_____
Parent Signature

APPENDIX E

Percent of Responses of Parents of Children in Kindergarten Through Fifth Grade to Questionnaire on Attitudes and Use of Hand-held Calculators

Experimental Group

	Pretest			Posttest		
	Yes	No	NA	Yes	No	NA
1. Does someone in your household own a hand-held calculator?	88.4	11.6	0.0	91.7	8.3	0.0
2. Does the father in your household use a hand-held calculator in his work?	52.7	39.5	7.8	50.4	38.0	11.6
3. Does the mother in your household use a hand-held calculator in her work outside the home?	31.8	60.5	7.8	33.9	61.2	5.0
4. Is the calculator used by either or both parents when shopping?	11.6	88.4	0.0	16.5	83.5	0.0
5. Is the calculator used on the average more than two times per week by either parent in your household?	63.6	35.7	0.8	62.0	38.0	0.0
6. Is the calculator used on the average more than two times per week by any child in your household?	12.4	84.5	3.1	19.8	76.9	3.3
7. Do elementary school students in your household use a calculator on homework assignments?	10.1	79.1	10.9	9.1	77.7	13.2
8. Do middle school students in your household use a calculator on homework assignments?	8.5	20.2	71.3	3.3	29.8	66.9
9. Do high school students in your household use a calculator on homework assignments?	7.8	14.0	42.1	7.4	16.5	76.0
10. Do you think elementary school students should be allowed to use a calculator on homework assignments?	30.2	65.9	3.9	41.3	55.4	3.3

APPENDIX E (continued)

	Yes	No	NA	Yes	No	NA
11. Do you think middle school students should be allowed to use a calculator on homework assignments?	41.9	48.8	9.3	41.3	43.8	14.9
12. Do you think high school students should be allowed to use a calculator on homework assignments?	67.4	23.3	9.3	65.3	19.0	15.7
13. Are you in favor of the unrestricted use of calculators in the classroom by elementary students?	14.7	83.7	1.6	9.9	88.4	1.7
14. Are you in favor of the unrestricted use of calculators in the classroom by middle school students?	15.5	78.3	6.2	11.6	74.4	14.0
15. Are you in favor of the unrestricted use of calculators in the classroom by high school students?	31.0	62.0	7.0	23.1	61.2	15.7
16. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by elementary school students?	79.8	18.6	1.6	88.4	11.6	0.0
17. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by middle school students?	78.3	14.7	7.0	79.3	8.3	12.4
18. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by high school students?	80.6	7.8	11.6	80.2	5.8	14.0
19. Do you think elementary school students should be allowed to use a calculator on classroom tests?	18.6	76.7	4.7	19.8	76.9	3.3
20. Do you think middle school students should be allowed to use a calculator on classroom tests?	24.0	64.3	11.6	23.1	63.6	13.2
21. Do you think high school students should be allowed to use a calculator on classroom tests?	48.1	41.1	10.9	44.6	40.5	14.9

APPENDIX F

Percent of Responses of Parents of Children in Kindergarten Through Fifth Grade to Questionnaire on Attitudes and Use of Hand-held Calculators

Control Group

	Pretest			Posttest		
	Yes	No	NA	Yes	No	NA
1. Does someone in your household own a hand-held calculator?	88.3	10.8	0.9	94.7	5.3	0.0
2. Does the father in your household use a hand-held calculator in his work?	45.9	39.6	14.4	48.9	42.6	8.5
3. Does the mother in your household use a hand-held calculator in her work outside the home?	34.2	61.3	4.5	41.5	55.3	3.2
4. Is the calculator used by either or both parents when shopping?	18.0	79.3	2.7	16.0	83.0	1.1
5. Is the calculator used on the average more than two times per week by either parent in your household?	53.2	42.3	4.5	60.6	37.2	2.1
6. Is the calculator used on the average more than two times per week by any child in your household?	16.2	80.2	3.6	13.8	81.9	4.3
7. Do elementary school students in your household use a calculator on homework assignments?	4.5	84.7	10.8	6.4	86.2	7.4
8. Do middle school students in your household use a calculator on homework assignments?	8.1	36.9	55.0	5.3	39.4	55.3
9. Do high school students in your household use a calculator on homework assignments?	12.6	26.1	61.3	12.8	24.5	62.8
10. Do you think elementary school students should be allowed to use a calculator on homework assignments?	23.4	67.6	9.0	29.8	69.1	1.1

APPENDIX F (continued)

	Yes	No	NA	Yes	No	NA
11. Do you think middle school students should be allowed to use a calculator on homework assignments?	39.6	46.8	13.5	45.7	47.9	6.4
12. Do you think high school students should be allowed to use a calculator on homework assignments?	64.0	23.4	12.6	70.2	21.3	8.5
13. Are you in favor of the unrestricted use of calculators in the classroom by elementary students?	17.1	77.5	5.4	16.0	81.9	2.1
14. Are you in favor of the unrestricted use of calculators in the classroom by middle school students?	19.8	71.2	9.0	21.3	72.3	6.4
15. Are you in favor of the unrestricted use of calculators in the classroom by high school students?	27.9	59.5	12.6	37.2	54.3	8.5
16. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by elementary school students?	72.1	26.1	1.8	75.5	24.5	0.0
17. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by middle school students?	73.0	18.0	9.0	80.9	14.9	4.3
18. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by high school students?	79.3	9.9	10.8	81.9	10.6	7.4
19. Do you think elementary school students shcuild be allowed to use a calculator on classroom tests?	16.2	76.6	7.2	20.2	77.7	2.1
20. Do you think middle school students should be allowed to use a calculator on classroom tests?	26.1	62.2	11.7	30.9	63.8	5.3
21. Do you think high school students should be allowed to use a calculator on classroom tests?	46.8	43.2	9.9	53.2	38.3	8.5

APPENDIX G

Percent of Responses of Parents of Children in Kindergarten Through Fifth Grade to Questionnaire on Attitudes and Use of Hand-held Calculators

Total Group

	Pretest			Posttest		
	Yes	No	NA	Yes	No	NA
1. Does someone in your household own a hand-held calculator?	88.3	11.3	0.4	93.0	7.0	0.0
2. Does the father in your household use a hand-held calculator in his work?	49.6	39.6	10.8	49.8	40.0	10.2
3. Does the mother in your household use a hand-held calculator in her work outside the home?	32.9	60.8	6.3	37.2	58.6	4.2
4. Is the calculator used by either or both parents when shopping?	14.6	84.2	1.3	16.3	83.3	0.5
5. Is the calculator used on the average more than two times per week by either parent in your household?	58.8	38.8	2.5	61.4	37.7	0.9
6. Is the calculator used on the average more than two times per week by any child in your household?	14.2	82.5	3.3	17.2	79.1	3.7
7. Do elementary school students in your household use a calculator on homework assignments?	7.5	81.7	10.8	7.9	81.4	10.7
8. Do middle school students in your household use a calculator on homework assignments?	8.3	27.9	63.8	4.2	34.0	61.9
9. Do high school students in your household use a calculator on homework assignments?	10.0	19.6	70.4	9.8	20.0	70.2
10. Do you think elementary school students should be allowed to use a calculator on homework assignments?	27.1	66.7	6.3	36.3	61.4	2.3

APPENDIX G (continued)

	Yes	No	NA	Yes	No	NA
11. Do you think middle school students should be allowed to use a calculator on homework assignments?	40.8	47.9	11.3	43.3	45.6	11.2
12. Do you think high school students should be allowed to use a calculator on homework assignments?	65.8	23.3	10.8	57.4	20.0	12.6
13. Are you in favor of the unrestricted use of calculators in the classroom by elementary students?	15.8	80.8	3.3	12.6	85.6	1.9
14. Are you in favor of the unrestricted use of calculators in the classroom by middle school students?	17.5	75.0	7.5	15.8	73.5	10.7
15. Are you in favor of the unrestricted use of calculators in the classroom by high school students?	29.6	60.8	9.6	29.3	58.1	12.6
16. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by elementary school students?	76.3	22.1	1.7	82.8	17.2	0.0
17. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by middle school students?	75.8	16.3	7.9	80.0	11.2	8.8
18. Are you in favor of the regulated use of calculators as an instructional aid in the classroom by high school students?	80.0	8.8	11.3	80.9	7.9	11.2
19. Do you think elementary school students should be allowed to use a calculator on classroom tests?	17.5	76.7	5.8	20.0	77.2	2.8
20. Do you think middle school students should be allowed to use a calculator on classroom tests?	25.0	63.3	11.7	26.5	63.7	9.8
21. Do you think high school students should be allowed to use a calculator on classroom tests?	47.5	42.1	10.4	48.4	39.5	12.1

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